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ABSTRACT

The history of a Biological Sciences Curriculum Study project which developed procedures for producing instructional modules is outlined, the 33 critical steps in the developmental sequence are shown diagrammatically, and some steps are described in the text. The relationship of these tasks to the theoretical curriculum development literature is shown, and their application to the preparation of a pilot module, The Environment of Man, in a sequence of units with the theme: Man as a biological and social organism living in a finite environment, is described. The general objectives of the series intended for general high school students and a synopsis of the intended contents of the other seven modules are provided, together with a detailed specification of the objectives specific to the pilot module. A description of the student and teacher materials in the pilot module is given, and a model for field testing the materials for a formative evaluation described, although this was not completed when the report was prepared. Two attachments, Teachers Instructional Handbook for "Investigating Your Environment" and Student Response Book for "Investigating Your Environment," referred to in the text were not included in this collection. (AL)

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FINAL REPORT

Project No. 9-0087

Grant No. OEG-8-9-150087-4007 (010)

A MODEL FOR IMPROVING BIOLOGICAL EDUCATION IN THE '70'S

An Experimental Module Dealing with the Environment of Man

William V. Mayer
Biological Sciences Curriculum Study
University of Colorado
P.O.Box 930
Boulder, Colorado 80302

October 15, 1970

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The research reported herein was performed pursuant to a grant with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

Preface

Implementation of educational theory, research and innovation continues to move at a much slower pace than contemporary society demands. The significant and continuing challenge to the Biological Sciences Curriculum Study is to keep pace with and adjust to the rapidly changing concerns and needs of the society it serves.

Such a challenge was posed by the recent resurgence of concern about the environment. Traditional conservationists were augmented by a new breed of ecologists whose warnings about the rapid deterioration of the finite resources of the earth began to be heard. As a consequence of this new interest and concern, educators have begun to look for effective ways to inform and appraise the public of the true nature of the "crisis," if there is one, and of the problems that must be solved if world-wide catastrophe is to be averted.

The Biological Sciences Curriculum Study, as part of a proposed new modular program in biology for the general education student, has attempted in this study to begin to meet this challenge of concern with the ecology of man.

William V. Mayer, Director

Acknowledgments

This project could not have been completed without the special assistance of numerous individuals who served in various capacities as consultants. Their counsel and contributions provided at critical intervals as the project developed made possible its conceptual framework and much of the substance of the final products.

The Ad Hoc Advisory Committee assisted the project staff in formulating the priorities and overall perspective for the project.

Ad Hoc Advisory Committee

James V. McConnell, Chairman
University of Michigan
Ann Arbor, Michigan

Arden D. Grotelueschen
University of Illinois
Urbana, Illinois

F. Michael Connelly
University of Toronto
Toronto, Ontario, Canada

O.J. Harvey
University of Colorado
Boulder, Colorado

John M. Emlen
State University of New York
Stony Brook, New York

Robert M. Thornton
University of California
Davis, California

The committee on objectives reviewed and assisted the staff in refining the terminal and subordinate objectives for the pilot environment module.

John A. Moore
University of California
Riverside, California

Haven Kolb
Hereford Jr.-Sr. High School
Parkton, Maryland

Bruce Wallace
Cornell University
Ithaca, New York

The four-day writing conference provided the initial set of techniques to be included in the student materials.

Writing Conference Participants

William C. Fraser
Sheldon High School
Eugene, Oregon

Raymond A. Gerdes
Texas Woman's University
Denton, Texas

Gaylord L. Hall
Mercer Island High School
Mercer Island, Washington

Walter E. Howard
University of California
Davis, California

Writing Conference Participants (Continued)

Edward F. Kelly
University of Illinois
Urbana, Illinois

Harold G. Liebherr
Nicolet High School
Milwaukee, Wisconsin

Alan H. McGowan
Washington University
St. Louis, Missouri

Robert F. Miller
Western New Mexico University
Silver City, New Mexico

Thomas C. Mohr
Terra Nova High School
Pacifica, California

Robert B. Peyton
Westview High School
Kankakee, Illinois

John L. Pusztai
Chino High School
Chino, California

Joe M. Steele
University of Illinois
Urbana, Illinois

Robert W. Stegner
University of Delaware
Newark, Delaware

George C. Turner
California State College
Fullerton, California

Claude A. Welch
Macalester College
St. Paul, Minnesota

James A. Swan
University of Michigan
Ann Arbor, Michigan

Douglas G. Alexander
Chico State College
Chico, California

Clancy C. Gordon
University of Montana
Missoula, Montana

Several consultants assisted the staff in developing the formative evaluation design and the selection and preparation of evaluation instruments for the pilot module.

Edward F. Kelly
University of California
Davis, California

Joe M. Steele
University of Illinois
Urbana, Illinois

Phil Bashook
University of British Columbia
Vancouver, British Columbia

Acknowledgments (Continued)

Special thanks are extended to Gilbert White, Delbert Elliott, and Richard Jessor of the Institute for Behavioral Sciences, University of Colorado, for their assistance with the development of social research techniques; to Herman D. Axelrod, Laboratory of Atmospheric Science, National Center for Atmospheric Research*; for his assistance with the development of the air quality techniques, and to Mrs. Janet Chu and her students at Fairview High School, Boulder, Colorado, for offering suggestions for revising several techniques.

Project Staff

Patrick E. Balch
Thomas J. Cleaver
Frederick A. Rasmussen
James T. Robinson

* Sponsored by the National Science Foundation.

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1. HISTORY OF THE PROJECT

Introduction

The original proposal for this project was submitted in July, 1968 and amended in January and in June of 1969. It was originally conceived to be part of a nationwide effort to provide model materials for education in the 1970's. This effort was guided by the Division of Comprehensive and Vocational Education and involved 17 "model" schools and other agencies that came to be known as the ES'70 (Educational Systems for the 70's) network. These schools and agencies were to design, test, and report on innovative models for improved instruction.

As originally submitted, this project proposed to:

a. Define performance objectives in terms of content, cognitive and affective behaviors consonant with the needs of the vocationally oriented population of students and with current societal concerns (Spring and Summer, 1969).

b. assimilate as many instructional modules as budgetary limitations would allow. These modules would reflect the outcomes, delineated as performance objectives, and would incorporate materials already in existence as well as those developed as part of the project (Academic year, 1969-70).

c. identify, modify, and develop instruments that measure both content achievements and changes in performance behaviors. It was considered feasible to develop, concurrently with objectives, the modes and instruments for evaluating instruction and pupil performance (Academic year, 1969-70).

d. train a group of test teachers and administrators for the use of the modules in five of the ES'70 model schools (Summer, 1970).

e. testing the modules in the five schools involving the students of the teachers trained in the summer programs. (Academic year, 1970-71).

f. revise the materials as indicated by the evaluation and conduct an expanded training program including biology teachers and administrators from all 17 of the ES'70 model schools (Summer, 1971).

g. test the revised modules in the 17 ES'70 model schools (Academic year, 1971-72).

Total funding requested for the three years of the project amounted to $385,396.00 with $90,010.00 budgeted for the first year's operations.

It should be noted that the success of the project was predicated upon the involvement of a number of committees acting in advisory capacities with a full-time project staff. These committees were to provide the project staff with a continuing source of expertise in, and evaluative comment upon, the procedures undertaken by the staff and upon the material produced.

Funding of the project was completed in June of 1969 in the amount of $75,000.00 with no commitment beyond the first year of operation. An amendment growing out of the short funding added $15,000.00 to the project in order to increase the first-year capability and to spread the work load more equitably over the hoped-for second and third years of the project.

Subsequent to entering into the contract agreement with USOE, several events of significance to the project occurred.

a. Staffing of the project was completed in July of 1969 and an ad hoc advisory committee was assembled to review initial staff proposals and planning. 1/ As a consequence of the two-day conference with this group, a prime focus was adopted for the project. This focus dealt with the need to consider Human Adaptability and Survival as a major biological and social concern. The need was established for selecting or developing materials that are relevant to the student, the teacher, and the society.

b. The advisory committee and staff concluded that with initial funding so low, devoting a full year to specifying objectives would not be as profitable as delineating the components of an instructional module, preparing a design for module development, and implementing the design by developing and producing one module. This plan would also serve to identify and suggest solutions to problems seen to be inherent in the requirement for formative evaluation of the materials produced.

c. There was, throughout the year 1969, an increasing cacophony of public concern and attention to the problems of population growth and environmental pollution. By September, 1969 it was obvious to the committee and staff that a pilot module on The Environment of Man would meet two major commitments of the project; 1) correspondence with immediate societal needs and concerns, and 2) it would offer a desirable medium for student application of inquiry process behaviors to an issue of both biological and social significance. Beyond these, it would test the project's ability to locate and assemble the relevant materials and literature needed for the module.

1/ See Acknowledgments for project consultants.

d. Also, during 1969 and continuing to the present, there has been a veritable flood of new books and articles related to problems of the environment and of hastily conceived materials purported to "teach" students about environmental problems and their solutions.

As a consequence of these events, the staff has repeatedly found itself working in the midst of a constantly changing environment almost devoid of stable conceptual frameworks and investigative techniques upon which an effective module to study the environment could be brought to fruition.

It is in this context that the first development year ends with the pilot module partially completed and essentially untested, but firmly based on guidelines that have evolved through repeated examination and evaluation. The excitement and approval of reviewers who have studied the progress reports, outlines, and preliminary materials attest firmly to the correctness of our directions and to the desire of biology teachers across the nation to work with materials of the type and quality described in this report.

Project Development Overview

Two recommendations proposed by the Ad Hoc Advisory Committee were the immediate concern of the project staff in the fall of 1969. The recommendation that environment be the initial area for development of curriculum materials initiated a literature search that quickly grew into an overwhelming activity. Letters were sent to the biologists on the BSCS Steering Committee to elicit their suggestions for the most cogent papers or books dealing with six particular aspects of the environment identified from the initial literature search. Responses to this letter were incorporated into an initial working bibliography of highly selected papers.

The second recommendation coming out of the Ad Hoc Advisory Committee meeting was the decision to abandon a textbook approach and to consider the specifications of what a teaching module could be, the components that a module should have, and how a module could be developed. The outcome of this line of activities led to the module development sequence and components of the module previously discussed.

An initial paper by Garrett Hardin, "The Tragedy of the Commons," served the function of the content narrative in the module development sequence.2/ This paper, a paper by Walter Howard, "The Population Crisis is Here Now," and a later paper by Beryl Crowe, "The Tragedy of the Commons Revisited," formed the essential elements of a content narrative for the shaping of the environment module.3/ 4/

2/ Science 162:1243-1248, December 13, 1968.

3/ BioScience 19:779-784, September, 1969.

4/ Science 166:1103-1107, November 28, 1969.

The staff developed several sequences of terminal objectives--objectives that specified what students would do during the course of instruction. The final sequence of objectives appear in "Investigating Your Environment," the teacher's instructional manual. With the specification of objectives, the task of developing a large number of techniques and ways in which students could investigate the quality and accessibility of a variety of aspects of the environment emerged as the task with which the staff would need technical assistance.

A writing conference to generate techniques was considered essential to bring together the variety of expertise required for this more technical aspect of module development. A small writing group was convened on February 16 and 17, 1970 to increase the specificity of the objectives of the module and to add detail to the objectives to assist a larger writing group convened on February 19 to February 22, 1970. Two consultants with skills in evaluation attended the conference to interact with the writing group and to develop a formative evaluation design for evaluating the module once it was ready for field testing.

The writing team produced over 50 techniques. However, these techniques were largely in the form of laboratory exercises, a form that the project staff was not to maintain in the module. Many of the activities within the techniques devised by the writing team proved to be useless or markedly incomplete.

Following the writing conference the project staff worked through the materials produced to search for environmental areas that were not adequately treated. No techniques were produced in the areas of social perceptions, attitudes and opinions, food, and technology. Only a limited number of techniques were produced for assessing air quality. Filling in the gaps and revising the techniques produced by the writing team, occupied the project staff for the remainder of the grant period. The project staff met with members of the Institute of Behavioral Sciences of the University of Colorado to discuss ways in which students could investigate social perceptions of environmental issues. This working session produced many ideas and resources that necessitated extensive follow-up, research, and development by the project staff. The staff also met with scientists at the National Center for Atmospheric Research* to develop techniques for assessing air quality.

The final activity in completing the prototype module was the collection of key papers that will back up the investigative techniques and that would extend the student's investigation beyond the classroom to the national and world scene.

* sponsored by the National Science Foundation

2. DESIGNS FOR DEVELOPMENT OF THE PROJECT

Background

Research in curriculum design and development is still in its infancy. In spite of the innovations apparent in the curriculum movements of the 1950's and 1960's, there have been few significant departures from the traditional model of the teacher textbook and laboratory manual. As a result, curriculum workers have noted few substantive changes in the behavior of teachers or in the quality of the learning generally taking place in science classrooms. Although the type and content of materials available from the BSCS and elsewhere was of considerable variety, the presence of the textbook supported the tendency of teachers to ignore other materials or to use them only to supplement traditional methods of using the text.

As a consequence of these observations, the BSCS chose to explore the possibilities of a non-text instructional program centering on specific and highly relevant content topics. These topics were to be organized into instructional modules that incorporated as many as possible of the constraints and guidelines for curriculum development and pupil-learning available in the research literature.

A Module Development Sequence

An analysis of this literature and the experiences of the staff led to the conception of a "Module Development Sequence" (Figure 1). This sequence served the project as an heuristic model to guide and to evaluate elements of the development process.

This task analysis and resulting flowchart established the following generalized procedural sequence for the staff:

Task 1: Examine and analyze current societal and educational concerns to determine a content focus for the module or modules consonant with relevant characteristics of the pupil population. Hence, the topic "The Environment of Man" was selected as a pilot module.

Task 2: Review related literature or text material having a direct bearing upon the conceptual content of a specific module. A synthesis of the findings of this literature search constitutes the "content narrative" and serves as a source document for the identification of content objectives.

Task 3: Develop a preliminary set of content and inquiry-process objectives based upon the content narrative, the BSCS conceptual view of inquiry, and the characteristics of the pupil population.

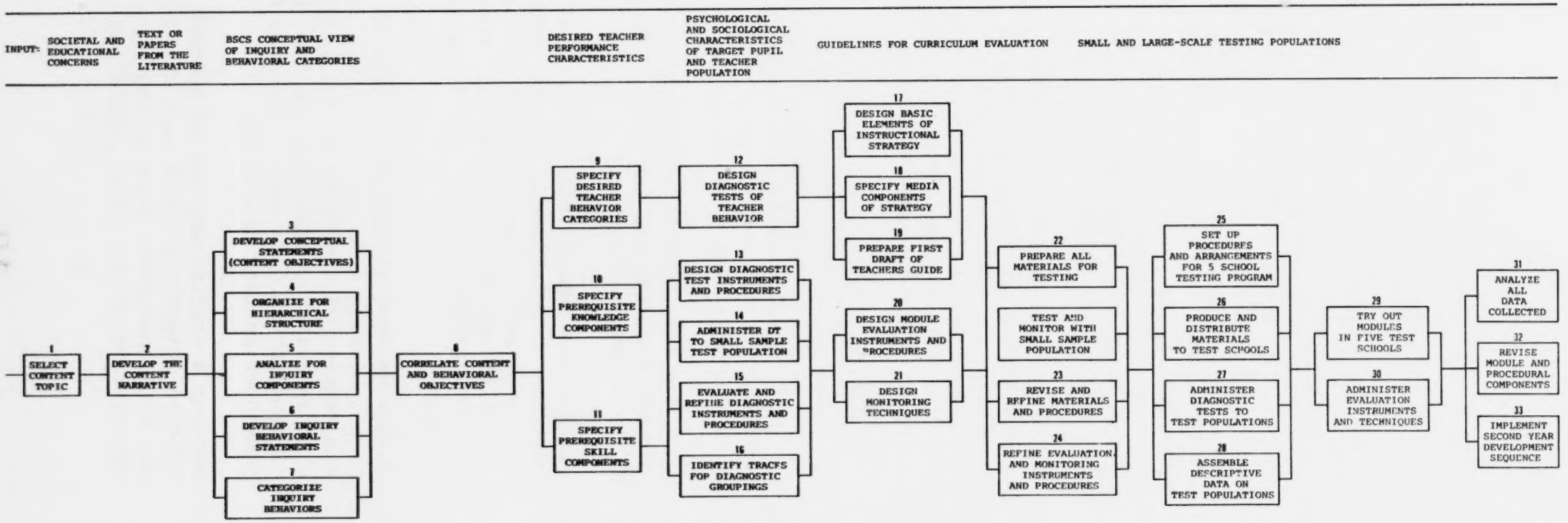

INPUT:
SOCIETAL AND EDUCATIONAL CONCERNS
TEXT OR PAPERS FROM THE LITERATURE
BSCS CONCEPTUAL VIEW OF INQUIRY AND BEHAVIORAL CATEGORIES
DESIRED TEACHER PERFORMANCE CHARACTERISTICS
PSYCHOLOGICAL AND SOCIOLOGICAL CHARACTERISTICS OF TARGET PUPIL AND TEACHER POPULATION
GUIDELINES FOR CURRICULUM EVALUATION
SMALL AND LARGE-SCALE TESTING POPULATIONS
1 SELECT CONTENT TOPIC
2 DEVELOP THE CONTENT NARRATIVE
3 DEVELOP CONCEPTUAL STATEMENTS (CONTENT OBJECTIVES)
4 ORGANIZE FOR HIERARCHICAL STRUCTURE
5 ANALYZE FOR INQUIRY COMPONENTS
6 DEVELOP INQUIRY BEHAVIORAL STATEMENTS
7 CATEGORIZE INQUIRY BEHAVIORS
8 CORRELATE CONTENT AND BEHAVIORAL OBJECTIVES
9 SPECIFY DESIRED TEACHER BEHAVIOR CATEGORIES
10 SPECIFY PREREQUISITE KNOWLEDGE COMPONENTS
11 SPECIFY PREREQUISITE SKILL COMPONENTS
12 DESIGN DIAGNOSTIC TESTS OF TEACHER BEHAVIOR
13 DESIGN DIAGNOSTIC TEST INSTRUMENTS AND PROCEDURES
14 ADMINISTER DT TO SMALL SAMPLE TEST POPULATION
15 EVALUATE AND REFINE DIAGNOSTIC INSTRUMENTS AND PROCEDURES
16 IDENTIFY TRACFS FOR DIAGNOSTIC GROUPINGS
17 DESIGN BASIC ELEMENTS OF INSTRUCTIONAL STRATEGY
18 SPECIFY MEDIA COMPONENTS OF STRATEGY
19 PREPARE FIRST DRAFT OF TEACHERS GUIDE
20 DESIGN MODULE EVALUATION INSTRUMENTS AND PROCEDURES
21 DESIGN MONITORING TECHNIQUES
22 PREPARE ALL MATERIALS FOR TESTING
23 REVISE AND REFINE MATERIALS AND PROCEDURES
24 REFINE EVALUATION AND MONITORING INSTRUMENTS AND PROCEDURES
25 SET UP PROCEDURES AND ARRANGEMENTS FOR 5 SCHOOL TESTING PROGRAM
26 PRODUCE AND DISTRIBUTE MATERIALS TO TEST SCHOOLS
27 ADMINISTER DIAGNOSTIC TESTS TO TEST POPULATIONS
28 ASSEMBLE DESCRIPTIVE DATA ON TEST POPULATIONS
29 TRY OUT MODULES IN FIVE TEST SCHOOLS
30 ADMINISTER EVALUATION INSTRUMENTS AND TECHNIQUES
31 ANALYZE ALL DATA COLLECTED
32 REVISE MODULE AND PROCEDURAL COMPONENTS
33 IMPLEMENT SECOND YEAR DEVELOPMENT SEQUENCE

Figure 1. Module Development Sequence

Task 4: Correlate content and inquiry objectives and organize them into hierarchical relationships that define a logical instructional or learning sequence.

Task 5: Describe desired teacher performance characteristics and specify those that are directly applicable to the objectives of the module under development.

Task 6: Specify prerequisite knowledge and skills that are required for successful pupil performance with the module materials and subject matter.

Task 7: Design and/or select diagnostic instruments to measure correspondence between actual pupil and teacher performance characteristics and prerequisite requirements of the module.

Task 8: Design and/or select instructional media and strategies that are most likely to elicit the kinds of pupil response behaviors defined by content and performance objectives.

Task 9: Predict and describe expected or desired pupil responses to the materials and strategies proposed.

Task 10: Administer, evaluate, and define diagnostic test instruments and identify tracks for diagnostic grouping of the field test populations.

Task 11: Prepare an experimental draft of a teacher's instructional manual incorporating pupil performance objectives, media components, teacher performance criteria, suggested strategies for instruction, and expected pupil response behaviors.

Task 12: Design and construct formative evaluation instruments and procedures and test with a small population for construct validity.

Task 13: Revise and prepare all experimental materials for pilot testing.

Task 14: Conduct orientation workshops for teachers and administrators of pilot test schools.

Task 15: Administer diagnostic tests to pilot test school teachers and pupils and assemble descriptive data on those populations.

Task 16: Pilot test the experimental materials.

Task 17: Analyze all data collected.

Task 18: Recycle procedural flow at those points indicated by an analysis of the evaluation data to revise the materials before retesting and final publication.

The significant evaluative components of this project are thus indicated to be primarily at Tasks 2, 10, 15, 16, and 17. Procedures at these and other points in the development sequence are based on tentatively acceptable data from the literature on curriculum development.

Defining Objectives

The literature and terminology used in objective specification is diverse and in many instances contradictory. What appears to be common to all who regard the specification of meaningful objectives as important to instruction and learning is the realization that it is a complex task. If we knew ahead of time exactly what knowledge was crucial for every learner at any given point in time, and exactly how to elicit the cognitive, psychomotor and affective behaviors that are most productive of maximum learning responses in every child with whatever content is used, there would be little need for the extensive, long-range research and evaluation efforts now facing the educational community. What we do know is that we must raise and test usable hypotheses with respect to learning and instruction and continually seek to validate those hypotheses through curriculum research.

Defining objectives is one way of stating hypotheses regarding the means and ends of the instructional endeavor. Regardless of how behaviors are defined or by what terms they are known, we are essentially desirous of obtaining empirical evidence of the effects of instructional interventions. The obtaining of such evidence requires a construct that is capable of interpretation and verification.

Psychological Assumptions

The BSCS staff has reviewed the significant literature on objective specification and has arrived at an adaptation that provides an adequate rationale for our present efforts. Some principles or assumptions on which elements of that rationale are based are:

a. Learning consists of the attainment of knowledge or skill or characteristic behavior as a consequence of using cognitive, affective, and/or psychomotor processes to sense, organize, and respond to internal or external environmental stimuli.

b. Human learning possesses characteristics that can be represented by linear and hierarchical constructs, although learning may not proceed in this manner.

c. Affective responses, such as interest, attitudes, and values are more attainable through active, participatory questioning styles of instruction, and through inquiry with meaning to the student, than through passive responses to didactic discourse.

d. To the extent that human behavior is learned and the total environment of learning is discernible and describable, modifying and predicting human behavior during and as a consequence of a planned instructional sequence is possible.

These principles (or assumptions) provide the basis for the generalized hypothesis that, given an attainable objective, described behaviorally, there is a combination of environmental stimuli (instructional materials and strategies) that can be effectively used to elicit a predicted learning response(s). (This does not preclude the occurrence of unpredicted responses of greater or lesser value than those planned for or predicted.) This hypothesis would further provide that repeated interventions during instruction that require or elicit the predicted response will result over a period of time in a higher level or frequency of the response after the instructional sequence than before. Figure 2 is a diagrammatic representation of this hypothesis.

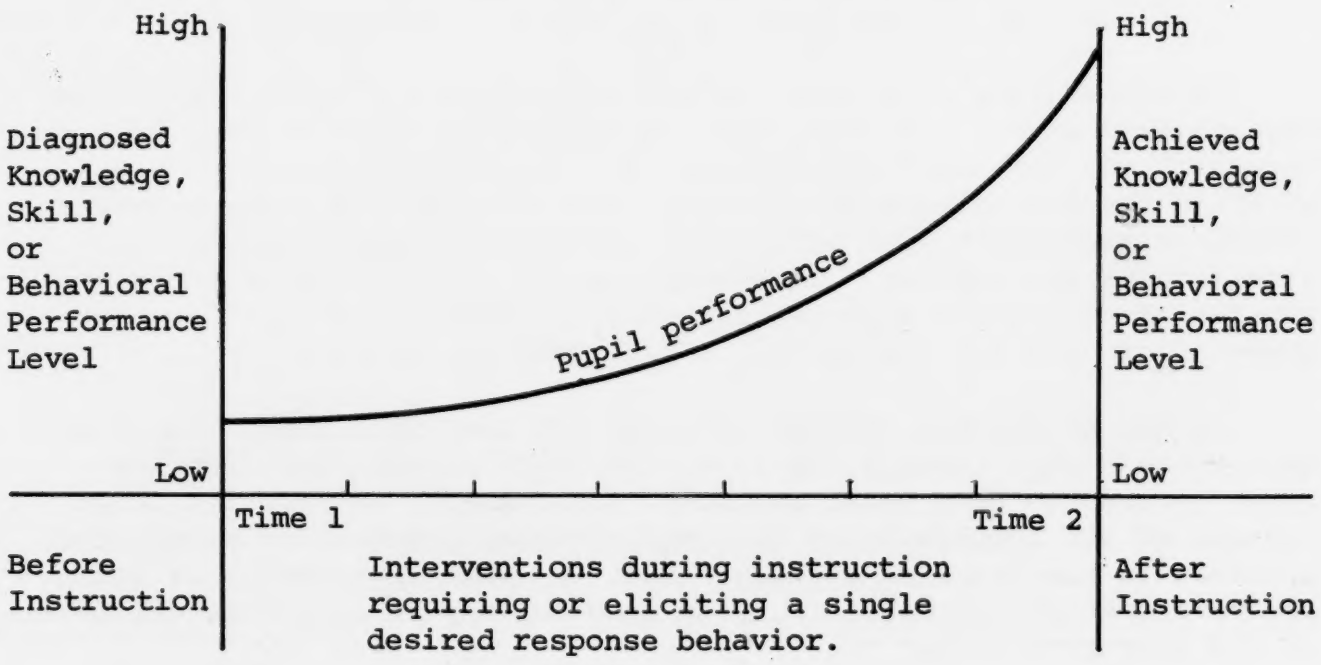


Figure 2. The Relationships between Instruction and Learning.

The structure of this model might suggest training rather than what is usually described as inquiry by many science educators today. However, if the desired response behavior is described in terms of categories of behavior such as those attributed to scientific inquiry--problem formulation, formulating hypotheses, designing studies, executing an investigation, interpreting data, and synthesizing knowledge--we can hypothesize that there can be sufficient correspondence with higher cognitive levels of understanding as opposed to lower level responses such as pushing a certain button in response to the appearance of a green light.

In this same context, demonstrating that higher level cognitive behaviors take on a hierarchical structure when analyzed for knowledge or skills will be possible. The postulation of a hierarchical nature of the learning process has been described in some detail by Gagne. He states in summary:

> Thus it can be seen that knowledge of the principles of a specific science topic requires the previous learning of subordinate principles that are general to science, in the sense that they deal with the processes of obtaining scientific information, regardless of whether this is biological, physical, chemical, or whatever. Moreover, these fundamental principles in turn necessitate the learning of prerequisite concepts...Science Learning, like mathematics learning, has a hierarchical structure that is crucially supported by a number of concepts and principles that are not content-specific; rather, they are general to the study of any and all sciences. 5/

From this base in theory, we can proceed to the task of defining objectives. We can logically begin by accepting the dichotomy of "process" and "content" objectives. The first encompasses the means by which the environment is perceived and organized, and the second refers to that particular bit of the environment that commands the attention of the learner. Thus there is the possibility of two hierarchies of objectives superimposed on each other. The first, a hierarchy of process and the second, a hierarchy of content.

It can be assumed, though this has not been confirmed, that learning proceeds best through the levels in these hierarchies from low level demands to high level demands. Confirmation becomes difficult because of the complexity of the cognitive and psychomotor structures involved in the learning process. That is, when approaching or attending to a specific problem, learning behavior may range across all levels of the hierarchy rather than sequentially through each level.

5/ Gagne, Robert M., Conditions of Learning. New York: Holt, Rinehart & Winston, 1965, p.190.

Process Hierarchy 6/

Content Hierarchy 7/

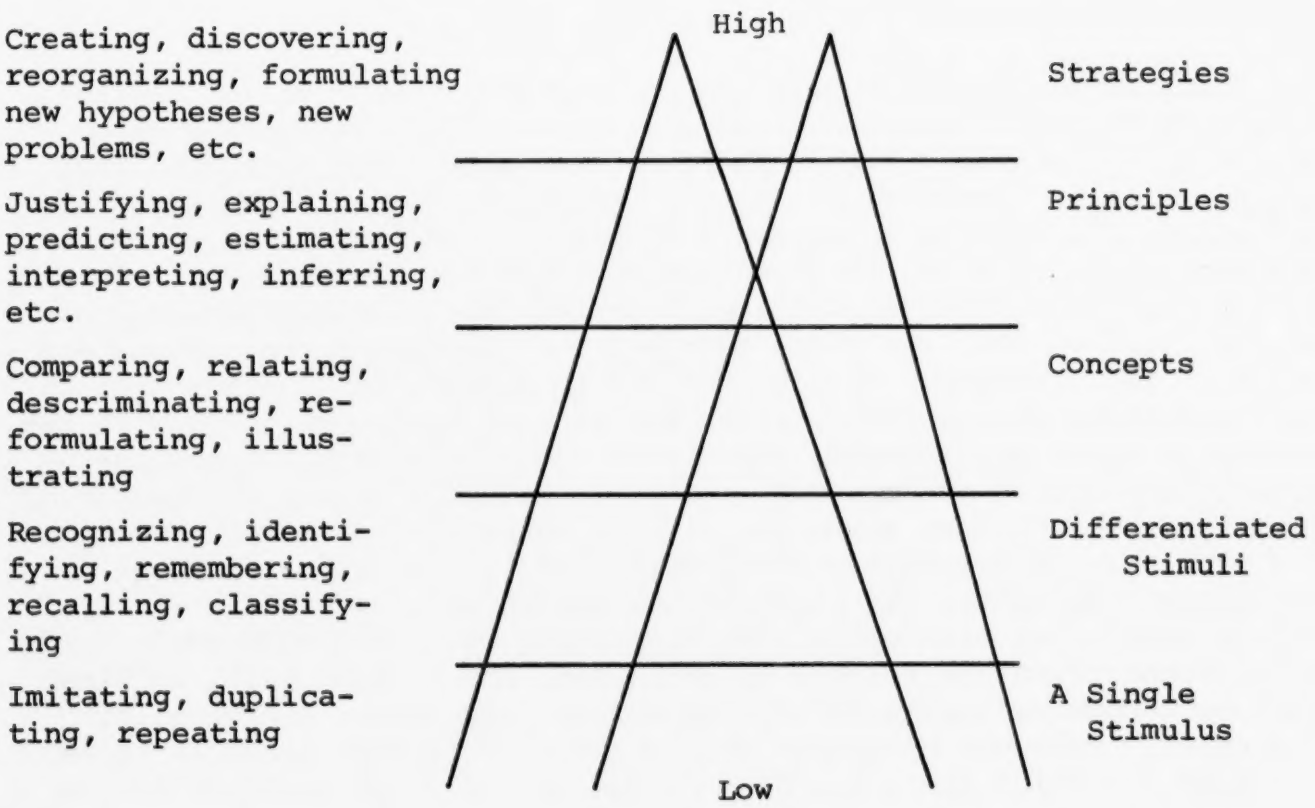


Figure 3. The Nature of Process and Content Hierarchies.

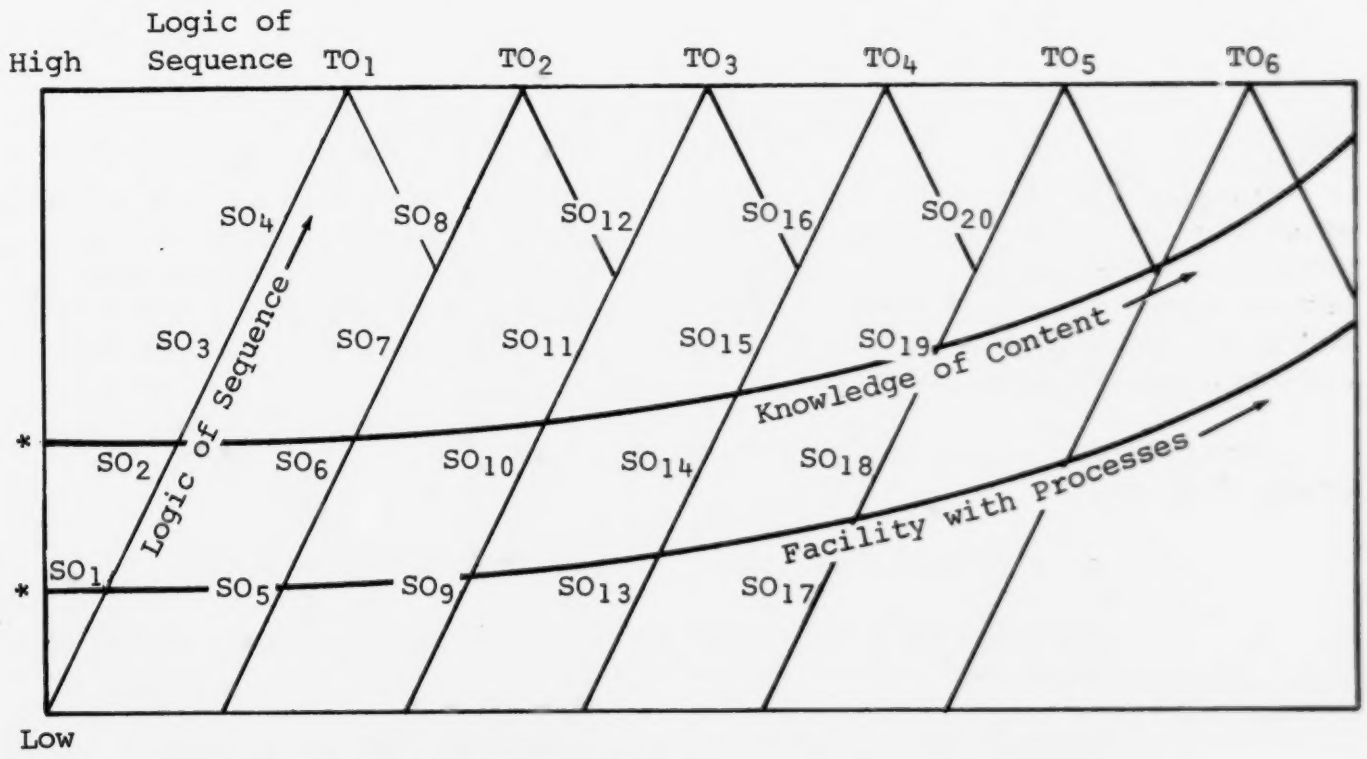
6/ Performance Scale adapted from James M. Bradfield and H. Stewart Moredock. Measurement and Evaluation in Education, New York: Macmillan Co., 1957, p.204.

7/ Content hierarchy adapted from Gagne, Robert M. "The Analysis of Instructional Objectives for the Design of Instruction," in Teaching Machines and Programmed Learning II, Robert Glaser (ed.) Washington, D.C.: National Education Association of the United States, 1965, p.55.

Since the task of designing instruction cannot accommodate an infinite variety of possible permutations, it nonetheless can structure the learning environment so as to maximize the effectiveness of a proposed design. This means attempting to determine by diagnosis the functional level reached by the learner or population of learners, using this level as an entry point, and proceeding through the scale of demands to the terminus of the hierarchy.

A second problem of sequencing that demands consideration is the definition of short- and long-term goals; or, to put it another way, the making of necessary distinctions between objectives to be attained during and after instruction. If our hypothesis regarding repeated interventions illustrated in Figure 2 is correct, we need to give greater attention to predicting the immediate consequences of our instructional interventions in order to adequately predict the long-term consequences. Thus, it follows that the terms terminal and subordinate objectives are useful in two contexts: 1) with short-term objectives, in reference to pupil responses during instruction, and 2) with long-term goals with reference to which all subsumed objectives are subordinate. A terminal objective, matching process and content goals, will have a sub-hierarchy of subordinates through which the student moves in seeking the solution to a problem. On subsequent days, with different problems of equal or increasing complexity, the student will repeatedly perform a variety of process tasks, but presumably with increasing skill and competence. If the problems given are related in principle, the student will, in time, begin to recognize similarities, conceptual structures, and finally, strategies. Pre-post diagnosis should show substantial gains in those learnings for which there has been enough reinforcement offered during instruction. Planning for short-term performance objectives should, therefore, bear a significant relationships to long-term behavioral goals. It is difficult, however, to determine a priori the point in time at which evidence of success with long-term behavioral goals should show significance when the goals to be measured are at high levels in the cognitive domain. This may explain why most achievement tests continue to depend upon recall items to reveal significance in testing and by this very act influence the nature and goals of instruction to emphasize memorization and regurgitation.

For these reasons, this project is committed to a developmental focus upon performance during instruction. By virtue of this focus, we use the terms terminal and subordinate to represent short-term performance objective sequences. Thus, an instructional module designed to consume five weeks of class time would have a sequence of terminal objectives, each having a hierarchy of subordinate objectives for which instructional and evaluative strategies must be designed (see Figure 4). These strategies will represent a reasonable mix of selected content, instructional materials, and/or teacher behavior designed to elicit immediate and observable responses from students indicating engagement with the content and process demanded by the desired performance objectives.



* angle of inclination unknown

Figure 4. Relationships of Terminal and Subordinate Objectives in an Instructional Sequence

Our experience indicates that development of terminal and subordinate performance objectives for a new and innovative instructional program requires that they be stated first in very general terms. The logic behind this requirement is that selection of appropriate materials and strategies should follow the specification of general response categories. That is to say, an objective specifies that students will, for example, discriminate between scientific reports that represent poorly conceived and properly conceived research studies; examples of these kinds of materials will need to be made available. These examples would preferably be taken from, or developed within, a topical framework that matches the content focus of the module. Subordinate objectives would relate, perhaps, to recognition of faulty procedures or premises, or to unjustified or unsupported assumptions, etc. Strategies would include ways to introduce the materials, focus student attention on them, and elicit the intended or desired behavioral responses.

Once these three elements are determined and tested and validated for the predicted response behavior, a more precise statement of all of the objectives is possible. Each objective statement could then include the description of the behavior, the context in which the behavior is to occur (the stimulus), and the quality that should be expected of a student's performance to indicate an acceptable level of mastery.

Selecting Materials and Strategies

Part of the criteria for the appropriateness of materials and strategies for use during instruction can be derived from the nature of the objectives themselves. The objectives, materials, and strategies must reflect the developer's knowledge of the student population for which the module is being designed, of the social and educational concerns of the society, and of the disciplines.

Criteria for suggested strategies in this program are, in general these. They must:

a. seek to maximize student interest and enthusiasm,

b. provide for actual student involvement in various modes of inquiry,

c. provide the flexibility necessary for use in a variety of geographical areas with a variety of student types,

d. avoid, whenever possible, the use of didactic discourse as a means of information transfer,

e. provide for individual, small and large group experiences at points where they are deemed likely to provide the greatest benefit to individual learners,

f. seek to affect in a positive direction student attitudes about their capabilities to cope with real problems, and

g. seek to affect in a positive direction student attitudes about their capabilities to influence decision-making.

3. THE PHILOSOPHICAL BASIS FOR THE PROPOSED MODULAR PROGRAM IN GENERAL BIOLOGY FOR HIGH SCHOOL

Purposes of the Program

The long-range goals of this project were derived from early deliberations of the project staff and advisory committees. The focus derived from these discussions was upon the production of flexible program in the biological sciences for non-college-bound secondary school students. The suggested design involved the production and evaluation of a series of eight instructional modules--each of several weeks duration, some interdependent and sequential and others optional or independent.

Content of the Program

The program, as now conceived, will be approached from the perspectives of Man as a Biological and Social Organism Living in a Finite Environment. Essential threads spanning and correlating all modules include the major biological themes, such as evolution, the continuity of structure and function and the interrelationships of organism and environment. Other constraints are drawn from the characteristics, needs, and interests of vocationally oriented rather than college-bound students and the characteristics of contemporary society in which they live.

The core objective of this program is to have students develop increased awareness of and facility with the task of dealing with human problems. Therefore, the content is derived from the nature of man, his origins, his crucial life processes, and his behavior in response to physical and social environmental stimuli. Tentative objectives and preliminary descriptions of the eight proposed modules follow:

General Objectives for Modular Biology

a. to develop understandings of systematically selected concepts and generalizations of biology, especially those with relevance to the environment, and to develop skill in using them where they are useful in the solution of human problems, but specifically to:

   (1) explore ecological relationships, adaptation and survival, especially man's affects on the world ecosystem.

   (2) explore the conflicts and problems of determining biological species and types, especially the potential relationships between scientific knowledge and social practice regarding the races of man.

(3) explore the biological basis of behavior with special attention to the development of social and sexual behavior in primates and man.

(4) explore the human organism in comparison with other organisms.

b. to understand that biology as a science is a continuously developing, revisionary process, as well as a body of currently warranted fact and theory.

c. to understand that the structure of the discipline of biology that is being studied is only one of several possible structures, e.g.,

(1) appreciate the importance of different ways of looking at problems.

(2) examine the assumptions that form the basis of particular structures of biology.

d. to understand some of the ways in which scientific knowledge has grown in the past and is now growing and changing, and that the sciences only grow as individuals contribute to its growth throughout lifetimes.

e. to develop habits of thought characteristic of scientific inquiry and know the values and limitations of each, e.g.,

(1) recognize and distinguish dogmatic from critical appeal to authority and experience.

(2) recognize limitations in the evidence presented in competing arguments.

(3) recognize the principles of inquiry-guiding research and the influence of these principles on the knowledge produced.

f. to understand the kinds of questions that science as a way of thinking can and cannot answer; that biological knowledge can contribute to the solution of human problems, but recognize that all problems do not have scientific solutions. Man's failure to take account of the effects of science, rather than science itself, has resulted in social problems, such as pollution, population, etc.

g. to understand the close historical and contemporary relationships between scientific knowledge, technology,

natural resources, industry, and the standard of living and to know how science and scientific technology have and can improve man's health, longevity, and quality of life.

h. to provide opportunities for students to consider adult problems in a logical and fact-related fashion.

i. to develop independence in learning.

j. to continually evaluate science experiences for potential careers and for recreational opportunities, e.g.,

   (1) explore the relevance of scientific knowledge to nonscience careers.

   (2) explore the opportunities for semi-skilled, skilled and professional careers in science-related occupations.

   (3) examine areas of science that may serve recreational and avocational interests.

A Proposed Modular Biology Program

The proposed program will consist of eight modules of from four to six weeks each. Modules may be used independently in existing programs of instruction or the entire system of modules may be used for a full year of instruction. Each module is briefly described below, but will be subject to modification as the total program develops.

Each module will contribute to the development of biological skills of value to the average citizen in understanding man in the earth environment and contribute to his comprehension of environmental problems as they arise. In effect, Modules A to G serve as antecedents to an effective inquiry in Module H--The Environment of Man.

Module A. Man in Nature

The interrelationships among organisms and between organisms and environment are the central conceptions of this module. Students will investigate the components of ecosystems and explore selected relationships among environmental factors and biotic communities. They will also investigate energy and materials flow in limited biotic communities.

Module B. Who is Man?

This module will focus on the problem of biological species, with races of man as a case study. Inquiries will lead students into studies of human populations, variations within species, and gene

frequencies in populations. Such inquiries will lead back to Mendel, rather than begin with Mendel. The module will explore the relationships between social practices and scientific knowledge regarding the races of man.

Module C. Human Origins

This module will explore the question of man's origins, working backwards in time through the fossil record descriptively, raising the question of how this fossil record can be explained and to examine hypotheses regarding the origin of life. The gross structures of life functions of man will be examined and investigations of man's relations to the living world will be conducted. Man's cultural and social evolution will be studied in depth.

Module D. The Cycle of Human Life

The development of the human organism from egg through embryo, fetus, childhood, adolescence, and adulthood and aging will be investigated. Interactions of genetic and environmental factors in influencing the emerging organism will be considered, as well as selected environmental hazards to development, such as venereal diseases, selected drugs, radiation, and environmental deprivation.

Module E. Maintaining Human Life I

The effects of taking various substances into the body, and tracing these substances through the body will be introduced with a study of drug and narcotic effects. The differences between drug effects and nutrient effects will be investigated through a systems analysis of foreign body effects, including disease-inducing organisms and immune reactions. Relevant concepts of physiology, regulation, and homeostasis will be included.

Module F. Maintaining Human Life II

Maintenance of a species through time will be explored through courtship behavior in animals and reproductive behavior in primates and man. The biological processes of reproduction will be investigated through behavior, but will include the reproductive cycle as a self-regulating system. Psychological and social aspects of human sexuality will conclude the module.

Module G. Behavior

The biological roots of human behavior will be explored through inquiries into primate behavior and their origins. Problems of communications, use of tools and social behavior in man and other animals will be investigated. Special attention will be devoted to learning as a behavioral characteristic of animals, reaching its peak in man.

Module H. The Environment of Man

This module engages the student in investigating the quality and quantity of environmental factors that are relevant to his preferred life style. Investigations in his own community and analysis of data regarding the national and world status of these factors lead the student to formulate problems of human behavior on a finite earth. Alternative patterns of behavior, reflecting different values are explored for predictable consequences for human survival. This pilot module is attached to this report.

These modules are not presented here as a rigid sequence, except that Modules A to G are seen, in whatever order, as valuable antecedents to an effective inquiry in Module H, The Environment of Man.

This premise led the project staff to select Module H as the pilot module for development and evaluation. Apart from its timeliness in other respects, it offered possible insights into the content of the other modules as prerequisites.

4. CHARACTERISTICS AND COMPONENTS OF THE PILOT MODULE

Components

The pilot module nearing completion at the end of the first project year has two major material components:

a. Student materials consist of a manual titled Investigating Your Environment. The manual includes the following:

Chapter 1 - "Investigating Your Environment" describes the intent of the manual, what it contains, and how it can be used as a resource instrument.

The use and development of communication skills in at least three contexts is a part of the module experience for students. Students will participate in task-oriented discussions in small and large groups. These discussions will include expressing opinions, responding to the opinions of others, planning and designing investigations, and considering value-laden issues within a decision-making context. Another aspect of communications is the design, presentation, and criticism of research designs prepared for gathering information regarding carefully formulated problems. A final component of communications experience will be the preparation of materials and media to communicate the findings of investigations to classmates, to future classes, to members of the school community, and optionally, to the community at large.

Chapter 2 - "Techniques for Investigating Your Environment" provides background information and procedural guidelines for collecting environmental data from the student's local community.

This component of the environment module departs in educationally significant ways from the typical laboratory exercise, be it investigative or illustrative. The written materials provided to students present techniques and procedures for securing qualitative and quantitative data about the quality of the environment. Techniques for securing data on physical, biological, and social aspects of the environment are provided.

Unlike the conventional laboratory exercise, problem specification, selection of specific techniques relevant to the problem, and design of the investigation will be the task of the student. This departure from the usual

laboratory exercise is based on the assumption that students will be motivated to inquire when they formulate problems of significance to themselves, and that they will be able to explain what they are doing and why they are doing it when conducting investigations of their own design.

Chapter 3 - "Resource Papers on the Environment" is a collection of research reports and position papers carefully selected to provide the students with a broader outlook on environmental problems than would be available from his own studies of his local community.

These readings include scientific reports, interpretive articles, and articles from the popular media. No textbook or text-like materials are included. This departure from regular course materials is based on the assumption that the textbook format is typically uninteresting to students. Too often, text materials are summary statements, largely rhetorical in style.

The primary criterion for selecting papers for the module is their consistency with Schwab's conception of a "narrative of enquiry" as contrasted with a "rhetoric of conclusions." 8/ A second criterion for paper selection is substantive; the content must extend personal experience to national and whole-earth levels. As Boulding has made exceedingly clear,

> one of the great political problems arises from the tendency of people to generalize from their own personal experience to propositions about society as a whole. Formal education should teach people that their personal experience, important as it is to them, is a very imperfect sample of the totality, and we must give people an idea of how to sample this totality. 9/

Chapter 4 - "Designing an Investigation and Organizing for Teamwork" provides the student with carefully developed clues to the nature of scientific investigation, its crucial components and criteria for the selection of subjects and procedures.

8/ Schwab, Joseph J., "The Teaching of Science as Enquiry." Schwab, Joseph J. and Brandwein, Paul F. The Teaching of Science. Cambridge: Harvard University Press, 1962. pp.3-103.

9/ Boulding, Kenneth E., "Ecology and Environment." Trans-Action 5:38-44, March 1970. p.44.

b. The Teacher's Instructional Handbook

This book proposes a rationale and a set of procedural guidelines for the teacher. It proposes a sequence of events by which the module is introduced and by which student performance of the investigative procedures are to be initiated, monitored and, in some cases, guided. It suggests strategies for motivation, organizing activities and reports, and for leading discussion sessions on the data collected and the inferences to be drawn from the data.

The instructional handbook also contains a bibliography of papers selected to convey the point of view of the writers regarding environmental issues and pedagogy.

This module is an attempt to maintain a potentially precarious position between the personal involvement that seems essential to contemporary youth and the challenge to overgeneralization from that involvement. Again, as Boulding has stated,

> ...a widespread understanding of the nature of sampling error might preserve us from the literally deadly seriousness of cults of youth, radicalism, and the avant-garde. 10/

The rationale for instruction is presented in the Teacher's Instructional Handbook and is summarized in the next section.

10/ Ibid.

5. GENERAL OBJECTIVES AND RATIONALE FOR THE PILOT MODULE

The instructional strategies for the module have been arbitrarily subdivided into three phases for convenience in explanation:

Phase I Pre-Investigative Phase

Phase II Investigative Phase

Phase III Post-Investigative Phase

These divisions do not exist in the student materials and should not be used as referents to students. For them there should be one phase, investigating a scientific problem in which they have a personal interest and commitment.

The general objectives for this experimental module represent one way to engage students in a study of environmental problems in addition to providing experiences that will promote the idea of rational scientific investigation as a means of collecting useful data. These objectives, and the accompanying rationale, reflect some assumptions with regard to strategies and sequencing for maximum motivation.

PHASE I

Objective 1. Students will express value judgments relating to desired personal life-styles,

a. name things and/or circumstances that they value or consider necessary to the qualities of life they prefer.

b. discuss the judgments and desired life-styles of others in the class.

Objective 2. Students will relate life-style goals to environmental specifics,

a. specify environmental factors as they perceive them.

b. discuss the ways in which environmental problems seem to affect their life-styles or "favorite things."

Rationale, Phase I

It is assumed that every student attaches value to some material things or non-material relationships, i.e. having friends or being liked. A strategy that encourages free and open discussion of these "valued things or relationships" allows the student

to become emotionally involved as well as intellectually committed to identifying personal choices.

It is further assumed that, under proper instructional circumstances, students can be helped to trace each valued component of their personal life-style to a source directly related to external environmental factors.

The writers assume that students do not know that there are serious environmental problems in their own community and country. The meaning of know implies a comprehensive knowledge base that will enable the student to eventually formulate environmental problems rather than to accept the rhetoric of others. Avoidance of the concepts of pollution, overpopulation, etc., is essential to Phase I and II of this module.

The focus of Phase I is open discussion of valued life-styles (without prejudice) and relating these life-styles to student-identified environmental factors.

PHASE II

Objective 3. Students will (working in teams) formulate problems for investigation that relate to the quality and accessibility of the factor they would like to consider,

a. study (in teams) individual copies of the booklet "Investigating Your Environment."

b. prepare a list of researchable questions arising from their problem.

c. review and critique team questions.

Objective 4. Students will design and/or select procedures for the investigation,

a. search among the techniques provided in the resource booklet to determine if there is one relevant to their problem. If none exists, the problem may have to be reformulated or a new technique designed.

b. propose and present a rationale to support their selection based on characteristics of the local community.

c. organize into subteams as necessary and prepare research designs for the investigation of specific substances or situations.

d. review and critique research designs (within teams).

e. plan effective ways to display and communicate findings.

f. review and critique selected overall research designs.

Objective 5. Students will obtain qualitative and quantitative data,

a. secure, prepare, and practice with instruments and techniques to be used in their investigation.

b. conduct their planned investigations.

Objective 6. Students will analyze their data and draw inferences that reflect on the problem being investigated,

a. assemble and collate data from subteams.

b. identify substances, situations, or relationships that affect the quality of the environment they are investigating.

c. prepare reports and/or materials for communicating findings to the class.

d. present and discuss group findings or reports describing the status of those aspects of the environment they have investigated in the local community.

Objective 7. Students will attempt to identify immediate and/or long-term effects of variance from quality standards in the environment as it pertains to other problems,

a. prepare from their personal observations and from resource materials (film, papers, etc.) inferences as to immediate and long-term effects of quality variance.

b. analyze the inferences for their relationships to the data base.

Objective 8. Students will seek to formulate the fundamental causes that are contributing to variance from

quality standards and optimum availability of environmental factors,

a. identify natural and human elements acting on quality of the environment.

b. develop hypotheses which will attribute these to the common denominators--population growth, technological pollution, human attitudes and behavior.

Rationale, Phase II

Having established a "clear" relationship between valued lifestyles and one or more "crucial" aspects of the environment, we now assume that the average general education student has not been overly influenced by media attention to environmental problems. The instructional task is to encourage the students to take as unbiased a position as possible while examining the quality and availability of the aspects of the environment investigated as it affects the problem that concerns them. Beginning with a question such as: "Is there a difference in the quality of water resources?" or "Is there a difference in the ways schools treat kids?" the student can formulate a specific problem and research design to determine if quality variance exists in specific local situations and identify sources of variance if it is found. To facilitate these tasks, the student is given a set of techniques from which to choose--his choice again being based on specific local characteristics.

These tasks serve to engage the student in creative analytical thought processes along with the use of principles and practices of scientific research and analysis. The instructional task includes facilitating student efforts to obtain valid data by providing the equipment, arrangements, resources, and permissions needed.

The writers assume that data secured by students will have more significance (relevance) than that gathered by others. Primary emphasis is to be placed on investigations carried out by students. Using the data gathered by various agencies in the community should be seen as a less desirable alternative, but one that may provide essential data.

This phase departs from the usual science laboratory exercise by providing the student with techniques or criteria for developing techniques but not a problem or design. Problem formulation and the design of investigations is a difficult process. Permitting students time to think and providing encouragement to plan are necessary roles of the teacher. Care must be exercised to assist students around stumbling blocks without imposing the

teacher's problem and design on the students. Again, the writers assume that the process of problem formulation and the design of investigations is essential for student motivation, understanding, and commitment to the task.

The nature of the student investigations in many cases will require considerably more student freedom than that required in conventional science classes. The duration and frequency of such requests are not predictable before the formulation of the specific research designs. In many cases it is well to anticipate this dimension of the module and make the appropriate procedural and administrative arrangements. Certainly the apportionment of responsibility during the investigative phase of the module should be thoroughly explored with all students. When their investigations have been completed student displays and discussions of their findings should serve to draw attention to the larger problem of human attitudes, values, and behavior that affect the quality of the environment.

At the end of Phase II, students will probably have first-hand knowledge that many of their personal concerns are outgrowths of more pervasive societal problems such as population growth or a rampant technology.

PHASE III

Objective 9. Students will, in the areas they have investigated, identify alternatives with regard to human behavior,

a. identify divergent points of view regarding problems such as population increase (birth control, technology, standard of living, resource depletion, etc. human attitudes and behavior (racism, apathy, opportunism, etc.).

b. suggest consequences of the proposed alternatives.

Objective 10. Students will, in the areas they have investigated, evaluate the alternatives identified,

a. critique suggested consequences on the basis of data from their investigations and from resource materials.

b. identify current gaps in knowledge that leave doubt with regard to the consequences of suggested alternative behaviors.

c. identify and make explicit the implied values related to divergent points of view.

Objective 11. Students will, in the areas they have investigated, suggest and/or initiate corrective courses of action as individuals and as groups,

a. identify choices for personal commitment or concern.

b. identify existing groups, local and national, representing various points of view.

c. describe and/or initiate plans for personal or group involvement.

Rationale, Phase III

It is not the function of these materials to represent or to propose value criteria. It is, however, considered important to help students to recognize that alternatives do exist and are strongly supported by different interest groups. Identifying these alternatives and the values represented should help to point out the divergence of value structures as they exist in almost any segment of a population.

When asked to review their own conceptions of a valued lifestyle in the light of these new data, students should be expected to experience the same frustrations and tendencies toward hypocrisy extant in the general population and to interact with each other in defense of particular positions.

Finally, the module terminates by remaining open-ended with respect to this divergence, but encourages responsible involvement based on a better understanding of the conditions and issues involved. Such involvement may take the form of group action, a realization that "I need to know more," "There are no simple solutions," "We need more research on _____," etc.

6. A FORMATIVE EVALUATION DESIGN FOR TESTING THE PILOT MODULE

Design

Any new departure in the generation of materials for use by public school students requires formative evaluation as an integral aspect of development. The unique contribution of curriculum projects materials in contrast to commercial materials is this inclusion of formative evaluation of prototype materials prior to putting them into final form for publication and distribution. The attached materials describe in a general way the evaluation program that is central to the development of effective instructional materials produced by the Biological Sciences Curriculum Study project. This model has been developed and has been used in producing curriculum materials by the BSCS. The model was developed as part of this project and preliminary selection and drafting of evaluation instruments was initiated.

This model suggests an intensive rather than an extensive field test design. Specification of the number of classrooms and teachers involved in the design would be determined by the desired generalizability of the findings and the extent of funding. The crucial fixed ingredient in funding is the development of instruments consistent with the course materials. Experience of the BSCS staff indicates that when new curriculum departures are made, in this case an interdisciplinary non-textbook program, existing tests and other data gathering instruments of most types are generally inadequate to the new task. The expertise required to generate the data collection instruments is as critical as the development of curriculum materials if valid and reliable materials are to be produced.

The appended design is provided as a model prepared to provide the data base on which recommendations for the extension and revision of materials may be formulated. The formative evaluation phase of the preparation of this environment module is essential for its completion; for the initial development has been carried as far as possible, short of classroom trials.

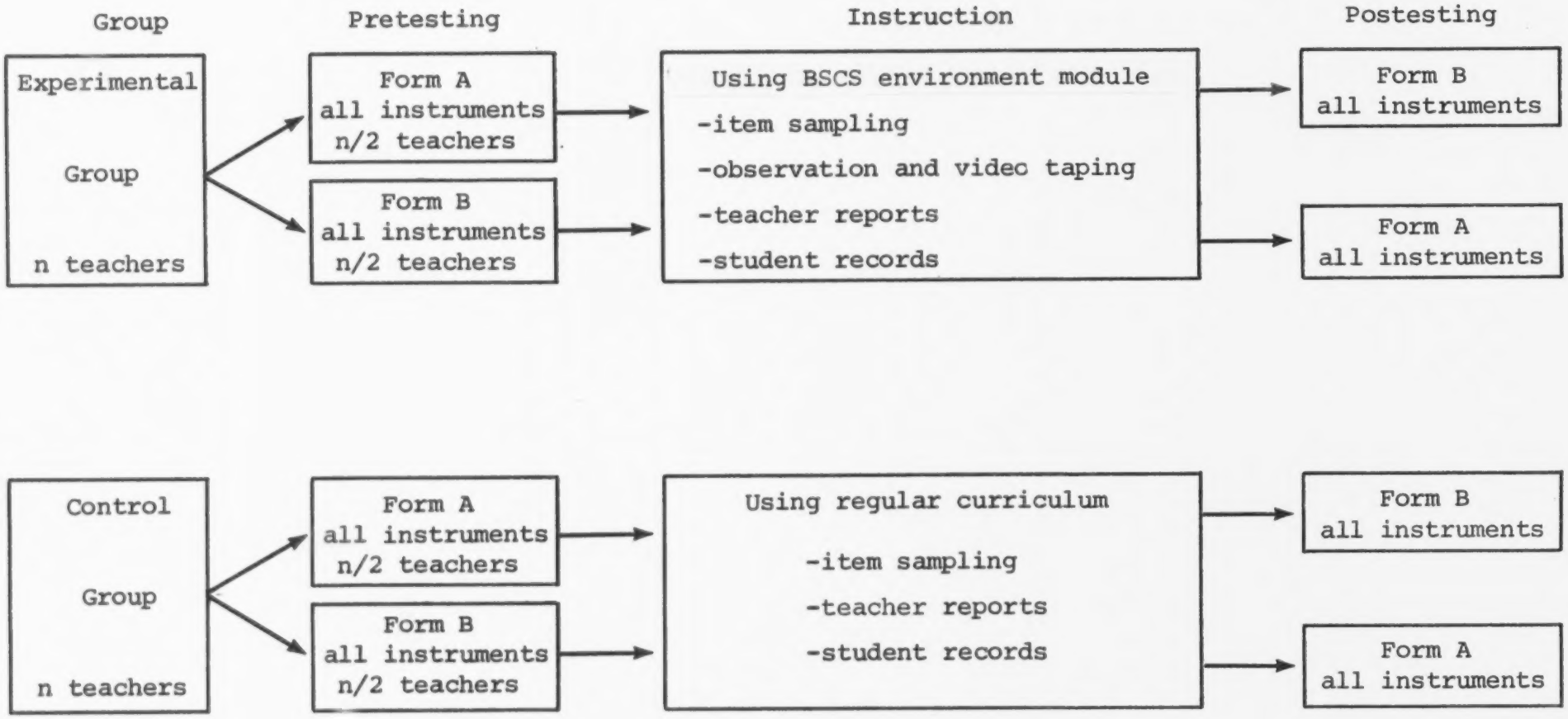


Figure 5. A Model for Field Testing of Course Materials

Antecedents: conditions existing prior to teaching and learning that may be related to outcomes.

Questions	Intentions	Data to be Collected	Instrument	Method of Data Processing
1. Was the "target population" appropriate for the materials?	The "target population" will be largely 10th grade with a general or vocational education orientation.	Name, age, grade level, course title, subjects taken, future goals, activities habits.	Student questionnaire (to be developed)	WD QUAP: Questionnaire. Analysis Program
2. Did the students have the requisite skills to implement the suggested teacher strategies?	Students will be able to: -formulate researchable problems -design experiments -utilize ecological knowledge in investigating environmental problems.	Pretest data.	Pretest-diagnostic test. (to be developed)	BMD and FORTAP Programs.
3. Did the teachers have the requisite skills to implement the suggested teacher strategies?	Teachers will be able to maintain inquiry model throughout instruction.	Responses of teachers and students to CAQ before and after use of module.	Classroom Activities Questionnaire (CAQ)	University of Illinois CAQ Analysis.
4. Were the classroom setting, school, and community conditions limiting or supporting to the execution of the module?	Teachers and administrators will modify rules to provide for necessary freedom for students to investigate environmental quality in the community.	Teacher reports Administrator reports (form to be developed)	Student questionnaire	WD QUAP: Questionnaire. Analysis Program

Table 1. A Formative Evaluation Model for the Environment Module

Transactions: the encounters of student with teacher, student with materials, teacher with materials, student with student.

Questions	Intentions	Data to be Collected	Instrument	Method of Data Processing
5. Were the teachers satisfied with the monogram materials?	Materials will be satisfactory.	Teacher reports for each material.	Teacher report form. (to be developed)	To be determined
6. Were the necessary community resources available?	Many resources will be available, identification will be made of those not available.	Teacher reports.	Teacher report forms. Teacher interviews. (to be developed)	To be determined
7. Did the teachers use certain materials and not others?	Teachers will select materials appropriate to their communities.	Teacher reports.	Materials use form.	To be determined
8. Did teachers use materials but unintentionally subverted their intent?	Some teachers may misinterpret the intended use of materials.	Observation records of materials use. Video taping of classes.	Trained observers and observation protocol. (to be developed)	To be determined
9. Were more resources, e.g., references, films, reprints etc., needed?	Not all potentially necessary resources will be included.	Teacher reports.	Resource need report form. (to be developed)	To be determined

Table 1. (Continued) A Formative Evaluation Model for the Environment Module

Transactions: the encounters of student with teacher, student with materials, teacher with materials, student with student. (Continued)

Questions	Intentions	Data to be Collected	Instrument	Method of Data Processing
10. Was the sequence of strategies optimal; should the teacher have been more (less) direct at a specific point; should he have gone to small groups when he did, etc.?	Additional data for alternative strategies will be produced.	Observation records. Video taping of classes.	Trained observers and observation protocol.	To be determined
11. Did the students inquire, e.g., observe, describe, formulate problems, etc.?	Students will exhibit a diverse range of inquiry behaviors.	Student-written materials. Observation records.	Protocol for analysis.	To be determined
12. Were students informed of their progress, i.e., what reinforcement schedule, grading procedures, etc., were used?	Students will be periodically assisted in evaluating their own progress.	Observation records. teacher evaluations of materials, etc.	Protocol for analysis.	To be determined

Table 1. (Continued) A Formative Evaluation Model for the Environment Module

Outcomes: the impact of instruction on teachers, students, administrators and parents.

Questions	Intentions	Data to be Collected	Instrument	Method of Data Processing
13. Did the intended student behaviors occur? If so, to what extent?	All students will exhibit some of the behaviors.	Observation records of student actions. Student reports. Objective Test Items.	Observation protocol. CAQ Objective Test	Not determined. University of Illinois CAQ Analysis. FORTAP program.
14. Did unintended student behaviors occur?	Unintended student behaviors will occur, some of which will be useful in revising the materials.	Observation records of student actions. Student reports.	Observation protocol.	To be determined
15. Did the intended teacher behaviors occur? To what extent?	Teachers will perform the intended behaviors or will devise alternative behaviors consistent with the curriculum design.	Teacher reports. Observation records.	Teacher report form. Observation protocol.	To be determined

Table 1. (Continued) A Formative Evaluation Model for the Environment Module

Outcomes: the impact of instruction on teachers, students, administrators and parents. (Continued)

Questions	Intentions	Data to be Collected	Instrument	Method of Data Processing
16. Was the module terminated without attempts to produce closure on single solutions to environmental problems?	Discussions of the consequences of alternative actions will avoid singular solutions.	Observation records. Cognitive postest scores. Attitude postest scores. Student reports.	Observation protocol. Cognitive postest. Attitude postest. (To be developed)	To be determined
17. Did the materials succeed?	The materials will be unevenly successful in the test classes.	Syntheses of all data collected.	Summary tables and data processing outputs.	Investigator's judgments.

Table 1. (Continued) A Formative Evaluation Model for the Environment Module

Data Gathering

Information on several questions proposed in formative evaluation design may be secured through administration of the Class Activities Questionnaire (CAQ). 11/ The CAQ assesses five major dimensions of instructional climate as presented in Table 2, page 38. The pattern of administration of the CAQ (see Table 1) will enable the investigators to determine changes in the classroom climate as perceived by students. Administration of the CAQ to the BSCS project staff to determine their ideal will provide a standard for comparing teacher ideal and teacher actual ratings. The structure of the CAQ is shown in Table 2.

Developmental work on the preparation of attitude-belief (A-B) scales was initiated during this project. The scales are based on the work of Fishbein and employ bipolar adjuctives in a modified form of Osgood's semantic differential. 12/ Fishbein provides both theoretical and operational definitions of beliefs and attitudes. Beliefs are defined as the probability dimension of a concept--is its existence probable or improbable? Attitude is defined as the evaluation dimension of a concept--is it good or bad?

Securing data on student beliefs and attitudes regarding specific concepts related to the basic course framework will provide useful information for revision of the course materials.

The concept statements listed below are examples of the concept statements that would be evaluated for use in field trials of the course materials.

a. My happiness depends on having all the material possessions I want.

b. World population is a serious problem now.

c. The United States should stop its population growth as soon as possible.

d. I prefer to live in the country with few people around me.

e. I prefer to live in the city among large numbers of people.

f. Learning about my body, how it works and changes.

g. Studying science.

11/ Instructional Climate in Illinois Gifted Classes. Illinois Gifted Program Evaluation, Center for Instructional Research and Curriculum Evaluation, University of Illinois, Urbana, Illinois, August 1970, p.10.

12/ Readings in Attitude Theory and Measurement. Martin Fishbein (ed.). New York: John Wiley and Sons, 1967.

Instructions for administering the attitude-belief scales conclude this section on formative evaluation.

*A	harmful	_____:_____:_____:_____:_____:_____	beneficial
A	wise	_____:_____:_____:_____:_____:_____	foolish
A	dirty	_____:_____:_____:_____:_____:_____	clean
**B	impossible	_____:_____:_____:_____:_____:_____	possible
B	false	_____:_____:_____:_____:_____:_____	true
B	existent	_____:_____:_____:_____:_____:_____	nonexistent
A	bad	_____:_____:_____:_____:_____:_____	good
B	probable	_____:_____:_____:_____:_____:_____	improbable
B	unlikely	_____:_____:_____:_____:_____:_____	likely
A	sick	_____:_____:_____:_____:_____:_____	healthy

*A = the attitude scales **B = the belief scales

Figure 6. The Attitude Belief Bipolar Adjective Scale

STRUCTURE OF THE CLASS ACTIVITIES QUESTIONNAIRE (CAQ) 13/

The CAQ assesses five major dimensions of instructional climate, as noted in the left-hand column. Each of these dimensions is composed of a number of factors which in turn are usually represented by several items in the questionnaire. (The Cognitive Dimensions are based on Bloom's Taxonomy.)

DIMENSIONS	FACTORS	BRIEF DESCRIPTIONS (Items not shown)
LOWER THOUGHT PROCESSES	1. Memory:	Activities calling for recall or recognition of information presented.
	2. Translation:	Activities calling for paraphrasing or expressing information in a different symbolic form.
	3. Interpretation:	Activities calling for recognition of relationships and seeing implications of information.
HIGHER THOUGHT PROCESSES	4. Application:	Activities calling for selection of appropriate methods and performance of operations required by problem situations.
	5. Analysis:	Activities calling for recognition of the structure of material, including the conditions that affect the way it fits together.
	6. Synthesis:	Activities calling for the generation of new ideas and solutions.
	7. Evaluation:	Activities calling for development and application of a set of standards for judging worth.
CLASSROOM FOCUS	8. Discussion:	Student opportunity for and involvement in class discussion.
	9. Test/Grade Stress:	High pressure to produce teacher-selected answers for a grade.
	10. Lecture:	Teacher role is information-giver with passive, listening role for students.

Table 2. Structure of the Class Activities Questionnaire (CAQ)

STRUCTURE OF THE CLASS ACTIVITIES QUESTIONNAIRE (CAQ) (Continued)

DIMENSIONS	FACTORS	BRIEF DESCRIPTIONS (Items not shown)
CLASSROOM CLIMATE	11. Enthusiasm:	Student excitement and involvement in class activities.
	12. Independence:	Tolerance for and encouragement of student initiative.
	13. Divergence:	Tolerance for and encouragement of many solutions to problems.
	14. Humor:	Allowance for joking and laughter in the classroom.
	15. Teacher Talk:	Proportion of class time consumed by teacher talk.
	16. Homework:	Weekly amount of outside preparation for class.
STUDENT OPINIONS	17. Qualities:	Students' view of the best things about the class.
	18. Deficiencies:	Students' view of things that need changing about the class.

Table 2. (Continued) Structure of the Class Activities Questionnaire (CAQ)

[illegible]

7. CONCLUSIONS AND RECOMMENDATIONS

The general purpose of this project was to produce model materials for biological education in the '70's. Although all of the goals of the project staff were not realized, the project produced such model materials. The constraints of time and fiscal resources made it impossible to provide a pilot module complete with all of the proposed components of a module as defined by the project staff. However, this very definition and design for instructional modules provides the framework for future materials that may provide for flexibility and individualization of instruction currently being proposed for improving education.

The project produced a pilot environment module for general high school biology students. This module consists of a Teacher's Instructional Handbook (see Attachment 1), and a student's resource book, Investigating Your Environment (see Attachment 2). In addition, a design for instructional modules, their components and development; and the framework for a complete modular program for high school biology were produced. These latter products have been described in this report.

The environment module is designed to engage students in active investigation of the quality and accessibility of environmental factors in their local community. Students will be engaged in individual and small group investigations designed to result in the identification of problems of environmental quality that face them as individuals and as members of society.

This module has several additional components to be completed before final classroom testing. The teacher strategies require an extension that will be developed after classroom testing, but the papers selected to extend student investigations need to be rewritten for the general high school tenth-grader. They exist now only in their original form as published in books, magazines, and journals.

A second major component to be completed is the design, production, and pilot testing of evaluative and diagnostic instruments.

A last component of the module is the media needed to provide alternative sources of information. The project staff reviewed most films and filmstrips currently available for environmental studies and found them incompatible with the investigative mode of the module objectives. The educational value of converting written materials into various kinds of media needs careful exploration. The time and cost of media development and production is many orders of magnitude greater than conveying the information in written modes. The educative value of media may also be greater, but research is needed to assist curriculum development groups to make decisions regarding the appropriate media to economically achieve particular objectives.

The interest and enthusiasm of both science and social studies teachers in the project and the numerous requests addressed to the BSCS about the module attest to the need for this material. Funding for field testing the environment module and for development and evaluation of the seven additional modules proposed here is considered by the BSCS to be of greatest priority in the improvement of biological education in the '70's.

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